Kasparov Versus Deep Blue: Computer Chess Comes of Age.

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Last month's victory of the IBM computer Deep Blue over world chess champion Garry Kasparov culminates a 22-year engineering effort. It was also a major sporting event.

Monty Newborn, who has been an active organizer of computer chess tournaments and helped arrange the Kasparov-Deep Blue matches, here recounts the 50 years of computer chess that led to the preceding, 1996, match, won by Kasparov.

Ideas about chess algorithms as well as advances in computer hardware were involved. However, it is a measure of our limited understanding of the principles of artificial intelligence (AI) that this level of play requires many millions of times as much computing as a human chess player does. Moreover, the fixation of most computer chess work on success in tournament play has come at scientific cost.

In 1965 the Russian mathematician Alexander Kronrod said, "Chess is the Drosophila of artificial intelligence." However, computer chess has developed as genetics might have if the geneticists had concentrated their efforts starting in 1910 on breeding racing Drosophila. We would have some science, but mainly we would have very fast fruit flies.

I mention three features of human chess play that are required by computer programs when they face harder problems than chess. Two of them were used by early chess programs but were abandoned in substituting computer power for thought.

1) Human chess players cannot examine all moves at every position they think about and therefore must forward prune the move tree and select the more promising moves for exploration; early chess programs also pruned. About 1969 forward pruning was eliminated, and computer power was relied upon to examine all moves. It made the programs work better, because early programs sometimes pruned good moves. Eliminating pruning was possible, because there are only about 40 moves in a position. In the game of Go, there are up to 361 moves in a position, so even computers must forward prune.

2) An early Soviet program could consider certain moves as analogous to moves that had been found to be bad in a parallel position. It would prune them unless something was observed that would rehabilitate them. This also was abandoned. Present programs spend most of their time rejecting the same moves millions of times apiece.

3) Human chess players often partition a position into subposition, for example the king's side and queen's side. We analyze the subpositions somewhat separately and then consider their interaction. Present chess programs only consider the position as a whole, and computer power makes up for the inefficiency. Computer Go programs are weak, because partitioning is absolutely necessary for Go. We yet don't know how to make computers partition effectively. Imagine playing wide chess on an 8-by-32 board. Humans would play almost as well as on the normal board by using partitioning, but programs based on present principles would be unable to search deeply.

Much would have been learned had these important intellectual mechanisms not been rejected for tournament chess programs.

Newborn developed chess programs named Ostrich between the 1960s and 1982, especially versions running on parallel processors. His book is an accurate history of tournament-oriented computer chess and explains many of the ideas present in today's programs. Like other chess books, it includes the scores of many of the important games. However, his conventional chess commentary takes almost no advantage of the possibilities computers offer to determine which lines of play were actually examined and how much time was spent on them.

Now that computers have reached world-champion level, it is time for chess to become a Drosophila again. Champion-level play is possible with enormously less computation than Deep Blue and its recent competitors use. Tournaments should admit programs only

with severe limits on computation. This would concentrate attention on scientific advances. Perhaps a personal computer manufacturer would sponsor a tournament with one second allowed per move on a machine of a single design. Tournaments in which players use computers to check out lines of play would be man-machine collaboration rather than just competition.

Besides AI work aimed at tournament play, particular aspects of the game have illuminated the intellectual mechanisms involved. Barbara Liskov demonstrated that what chess books teach about how to win certain endgames is not a program but a predicate comparing two positions to see if one is an improvement on the other. Such quantitative comparisons are an important feature of human intelligence and are needed for AI. Donald Michie, Ivan Bratko, Alen Shapiro, David Wilkins, and others have also used chess as a Drosophila to study intelligence. Newborn ignores this work, because it is not oriented to tournament play.

Research support agencies have trouble with the idea of chess as a Drosophila. When I explained to a DARPA program manager in the 70s how a student's program that discovered mating combinations contributed to recognition of complex patterns in general, he replied, "Well all right, but when he publishes his dissertation, would he kindly not acknowledge our support."

An extended commentary on making computer chess more scientific will be available at http://www-formal.stanford.edu/jmc/chess.html.

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